CLAIMS

1. An ultrafine crystal layer forming process of forming an ultrafine crystal layer in a surface layer portion of a surface of a workpiece constituted by a metallic material, by performing a machining operation on the surface of the workpiece using a machining tool, so as to impart a large local strain to the machined surface of the workpiece, the process being characterized in that:

the machining operation using the machining tool causes the machined surface of the workpiece to be subjected to a plastic working that causes the machined surface of the workpiece to have a true strain of at least 1.

2. The ultrafine crystal layer forming process according to claim 1, characterized in that:

the machining operation using the machining tool is performed with a material temperature at the machined surface of the workpiece being held lower than a predetermined upper limit temperature,

wherein the predetermined upper limit temperature is, where the workpiece is constituted by a steel material, an Ac1 transformation point of the steel material,

and wherein the predetermined upper limit temperature is, where the workpiece is constituted by the metallic material other than the steel material, substantially half a melting point of the metallic material as expressed in terms of absolute temperature.

3. The ultrafine crystal layer forming process according to claim 1, characterized in that:

the machining operation using the machining tool is performed with a material temperature at the machined surface of the workpiece being held within a predetermined temperature range,

wherein the predetermined temperature range is, where the workpiece is constituted by a steel material, not lower than an Ac1 transformation point of the steel material and is lower than a melting point of the steel material,

and wherein the predetermined temperature range is, where

the workpiece is constituted by the metallic material other than the steel material, not lower than substantially half a melting point of the metallic material as expressed in terms of absolute temperature and is lower than the melting point of the metallic material.

4. The ultrafine crystal layer forming process according to claim 3, characterized in that:

where the workpiece is constituted by the steel material, after the machining operation using the machining tool has been performed, the machined surface of the workpiece is cooled at a rate higher than a cooling rate that is required for hardening the workpiece.

5. The ultrafine crystal layer forming process according to any one of claims 2-4, characterized in that:

the machining operation using the machining tool is performed, such that a material temperature at the machined surface of the workpiece is held lower than the predetermined upper limit temperature or held within the predetermined temperature range, and such that a material temperature at a non-ultrafine crystal layer located in a lower layer portion of the machined surface or located in a surface layer portion in neighborhood of the machined surface is held at least about 500 C° for a length of time that is not larger than about 1 second, for providing the non-ultrafine crystal layer with a hardness that is about 80 % as high as a hardness of a substrate of the workpiece.

6. A machine component constituted by a metallic material and having a surface layer portion, the machine component being characterized in that:

the surface layer portion is at least partially provided by an ultrafine crystal layer formed by the ultrafine crystal layer forming process defined in any one of claims 1-5.

7. A machine component producing process of producing a machine component constituted by a metallic material and having a surface layer portion that is at least partially provided by an ultrafine crystal layer, the process being characterized by including:

at least an ultrafine crystal layer forming step of forming the ultrafine crystal layer in the machine component by the ultrafine crystal layer forming process defined in any one of claims 1-5.

8. A nanocrystal layer forming process of forming a nanocrystal layer in a surface layer portion of a surface of a workpiece constituted by a metallic material, by performing a machining operation on the surface of the workpiece using a machining tool, so as to impart a large local strain to the machined surface of the workpiece, the process being characterized in that:

the machining operation using the machining tool causes the machined surface of the workpiece to be subjected to a plastic working that causes the machined surface of the workpiece to have a true strain of at least 7, and is performed with a material temperature at the machined surface of the workpiece being held within a predetermined temperature range,

wherein the predetermined temperature range is, where the workpiece is constituted by a steel material, not lower than an Ac1 transformation point of the steel material and is lower than a melting point of the steel material,

and wherein the predetermined temperature range is, where the workpiece is constituted by the metallic material other than the steel material, not lower than substantially half a melting point of the metallic material as expressed in terms of absolute temperature and is lower than the melting point of the metallic material.

9. The nanocrystal layer forming process according to claim 8, characterized in that:

the machining operation using the machining tool is performed, such that a material temperature at the machined surface of the workpiece is held within the predetermined temperature range, and such that a material temperature at a non-nanocrystal layer located in a lower layer portion of the machined surface or located in a surface layer portion in neighborhood of the machined surface is held at least about 500 C° for a length of time that is not larger than about 1 second, for providing the nanocrystal layer with a hardness that is about 80 % as high as a hardness

of a substrate of the workpiece.

10. A nanocrystal layer forming process of forming a nanocrystal layer as a fine crystal grain layer in a surface of a workpiece constituted by a metallic material, the process being characterized by including:

performing a machining operation on the surface of the workpiece using a machining tool, so as to impart a large local strain to the machined surface of the workpiece, for producing the nanocrystal layer in a surface layer portion of the machined surface of the workpiece.

11. The nanocrystal layer forming process according to claim 10, characterized in that:

the machining operation using the machining tool causes the machined surface of the workpiece to be subjected to a plastic working that causes the machined surface of the workpiece to have a true strain of at least 7, and is performed with a material temperature at the machined surface of the workpiece being held not higher than a predetermined upper limit temperature,

wherein the predetermined upper limit temperature is, where the workpiece is constituted by a steel material, A1 and A3 transformation points of the steel material,

and wherein the predetermined upper limit temperature is, where the workpiece is constituted by the metallic material other than the steel material, substantially half a melting point of the metallic material as expressed in terms of absolute temperature.

12. The nanocrystal layer forming process according to claim 11, characterized in that:

the material temperature at the machined surface of the workpiece is held such that an overall time-based average value of the material temperature during the machining operation and an overall surface-based average value of the material temperature in an entirety of the machined surface over which a heat is distributed are not higher than the predetermined upper limit temperature.

13. The nanocrystal layer forming process according to any one of claims 8-12, characterized in that:

the machining operation using the machining tool is performed such that a strain gradient of at least 1/μm is imparted to the surface layer portion of the machined surface.

14. A machine component constituted by a metallic material and having a surface layer portion, the machine component being characterized in that:

the surface layer portion is at least partially provided by a nanocrystal layer formed by the nanocrystal layer forming process defined in any one of claims 8-13.

15. A machine component producing process of producing a machine component constituted by a metallic material and having a surface layer portion that is at least partially provided by a nanocrystal layer, the process being characterized by including:

at least a nanocrystal layer forming step of forming the nanocrystal layer in the machine component by the nanocrystal layer forming process defined in any one of claims 8-13.